CHAPTER 3 -- THE OPERATION OF LOADING-RACK METERING SYSTEMS

OBJECTIVES

After studying this chapter and reviewing its contents with your instructor, you will be able to:

1. Identify the major elements of a loading-rack metering system that are specifically involved in measuring and indicating quantity.

2. Describe differences in design and operating characteristics of these elements in typical systems that are encountered in the field.

3. Describe, in general terms, the operation of a positive-displacement metering device.

INTRODUCTION

In this chapter we will take a closer look at the major operating elements of a loading-rack metering system that are involved in measuring and indicating deliveries of product in commercial transactions, and with several other elements that are closely associated with them. A variety of designs are in common use, and new features are being incorporated in metering equipment almost continuously with advances in technology and changes in the marketplace.

In the interest of providing an introduction that is both thorough and comprehensible to the trainee who has not had extensive experience with these devices, we will not attempt to cover specific features of every model available from each of the manufacturers. You will acquire this specific knowledge most effectively through experience in the field. This chapter will instead focus on design features and operating characteristics that are common to the range of metering equipment you are most likely to encounter. In some cases, illustrations of particular designs are used. These are intended to help you to understand typical features, not to familiarize you with specific makes and models.

From the point of view of weights and measures enforcement and examination procedures the measuring and indicating elements are at the center of the system, as in a very real sense they are. However, as stressed in the last chapter, it is a misconception to think that accuracy of measurement depends exclusively upon the measuring and indicating elements: it bears repeating here that we are dealing with a <u>system</u> in which various components that perform different functions are dependent upon one another.

The system elements we will be concentrating on can be broken down into three groups, based upon their function: measuring element (meter), indicating and recording elements (register, automatic temperature compensator, printer), and flow control elements (air eliminator, system control valve, preset mechanism). We will consider each of these groups in turn.

MEASURING ELEMENT

Two types of meters are employed in most commercial loading-rack metering systems: positive-displacement meters and turbine meters. These types are not prescribed by regulation, and other types of meters have also found application in commercial use in recent years, such as the Coriolis-type mass flow meter. But in this module, we will concentrate on the two types you will encounter most frequently.

Handbook 44 requirements permit (and apply to) metering equipment that indicates in terms of units of weight (Mass Flow Meters) as well as to devices that indicate in terms of volume. However, sale by volume predominates in commercial loading-rack meter applications of the type that weights and measures officials most often encounter, and discussion in this course is limited to devices that indicate deliveries in terms of units of volume. Note, however, that meters that measure in terms of volume can be adapted to indicate in terms of weight provided density correction is included, and that meters designed to measure mass (weight) can be adapted to indicate in terms of volume. Therefore, a brief discussion of mass flow meters is included below.

Positive-displacement Meters

This is the same reliable and highly accurate method of measuring the volume of a flowing liquid that is used for other commercial liquid-measuring devices, such as gasoline pumps and vehicle-tank meters. The design of these meters is, from an engineering point of view, quite sophisticated, but their principle of operation is straightforward. The diagrams of several designs shown in Figures 3-1, 3-2, and 3-3 illustrate this principle.

Liquid product flowing through an enclosed space -- the meter chamber -- is momentarily separated into segments of known volume. The segments are then rejoined and flow from the meter into the discharge line. (In the meter cycles depicted in Figures 3-1 through 3-3, product that has been segmented is represented by darker shading.)

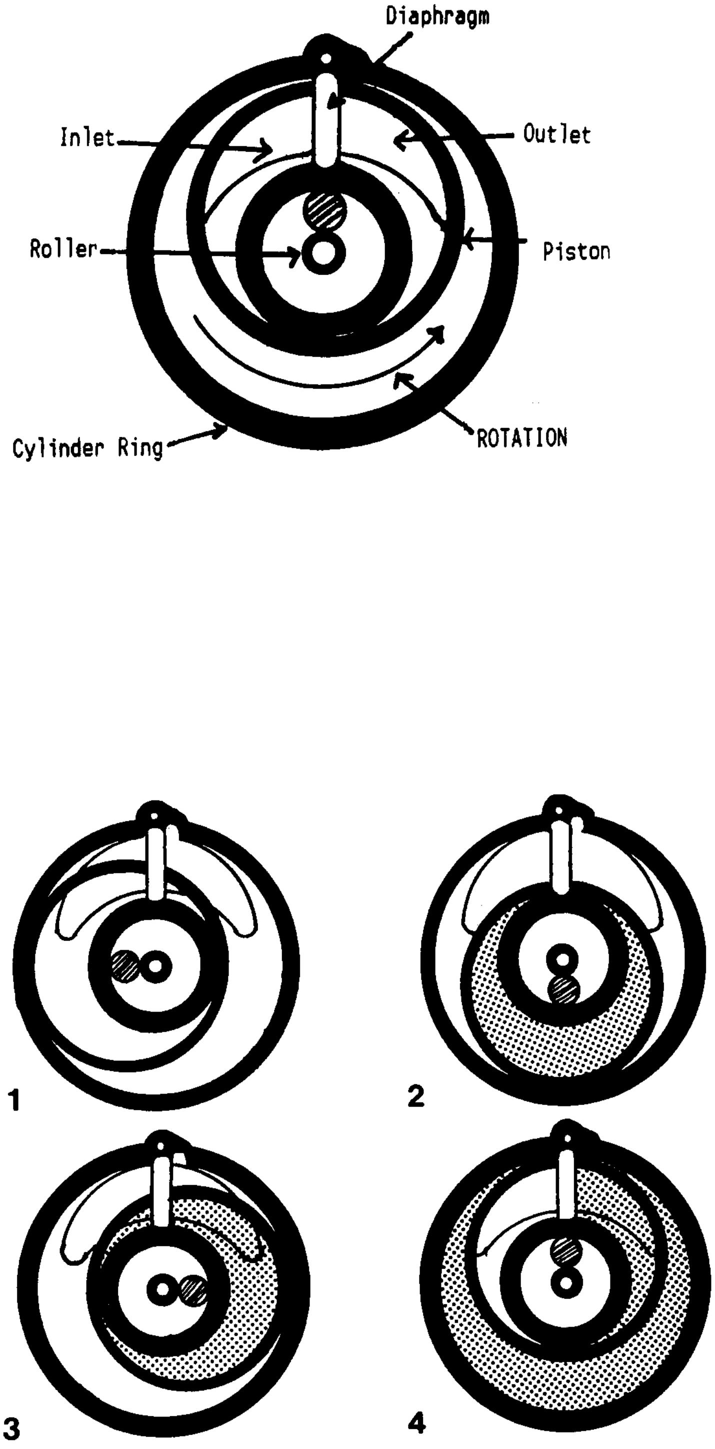
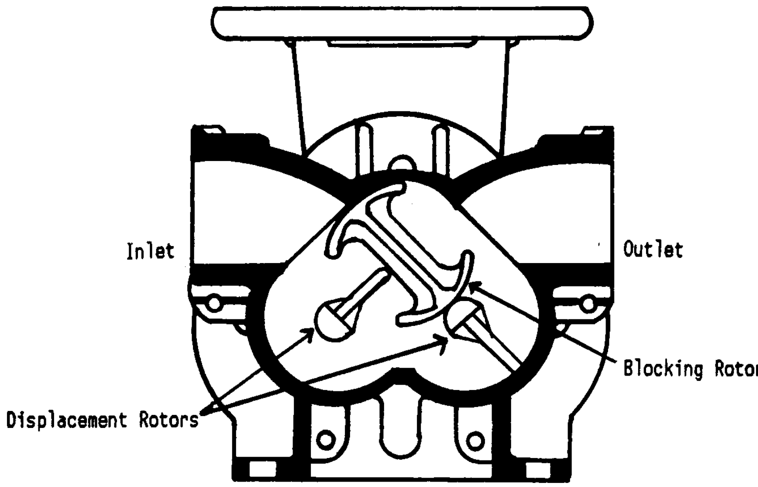


FIGURE 3-1. Principle of Operation of One Type of

Positive Dis-

placement Me- ter.



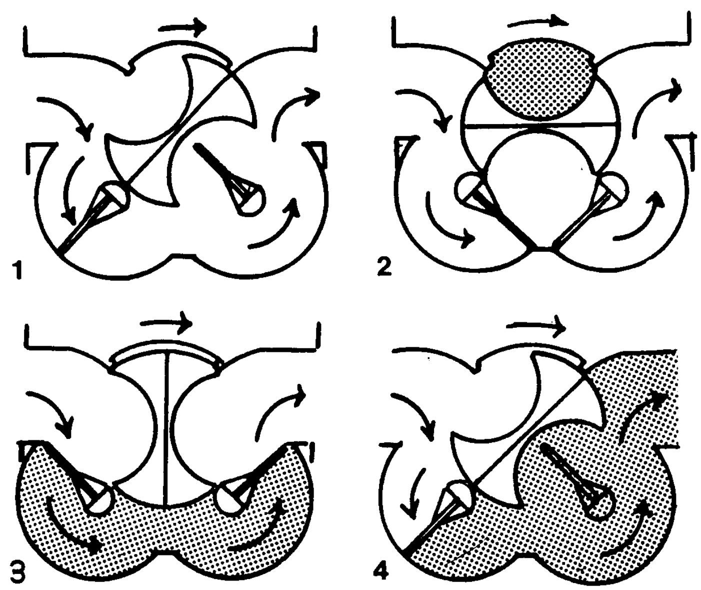


FIGURE 3-2. Principle of Operation of One Type of

Positive Displacement Meter.

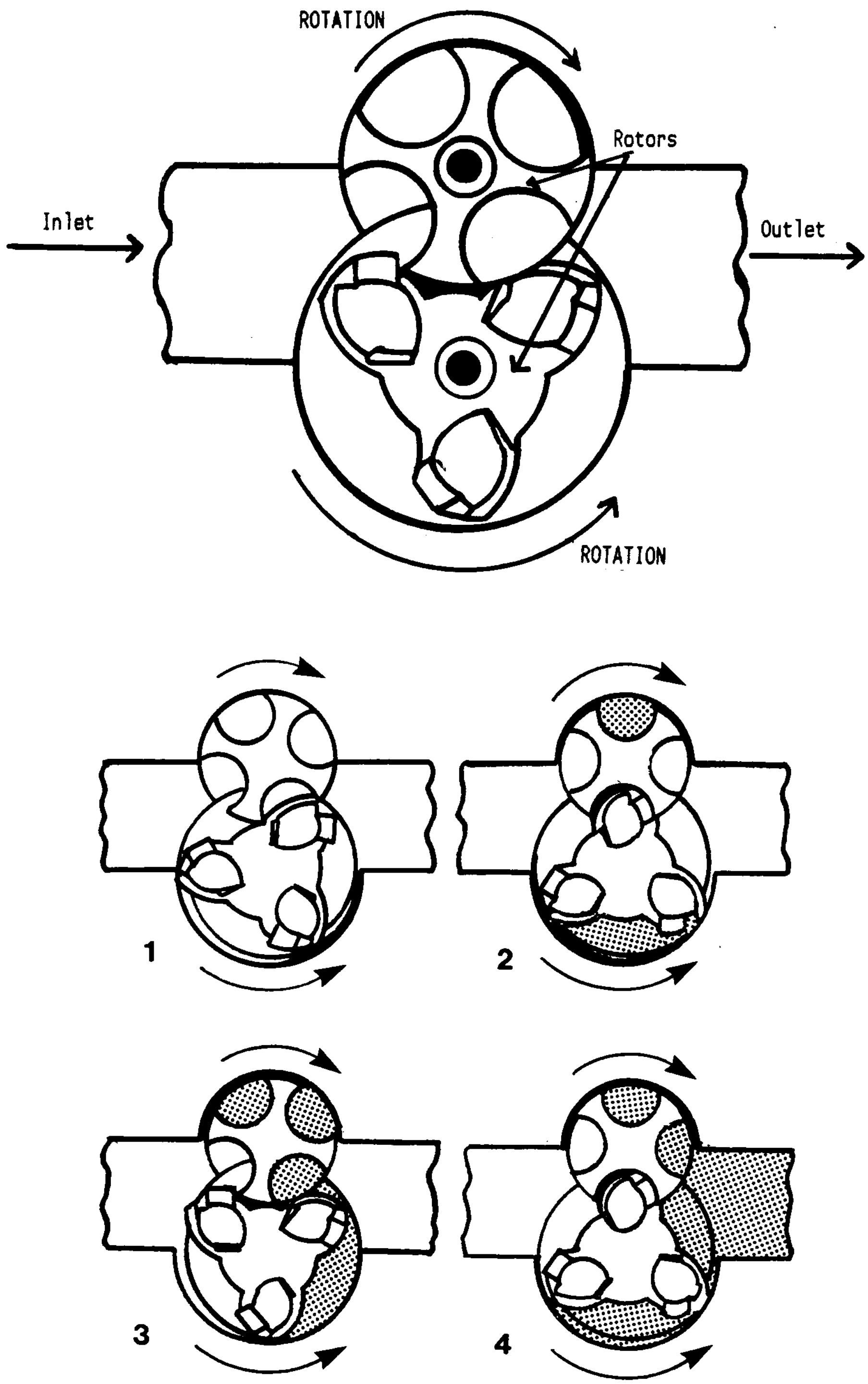


FIGURE 3-3. Principle of Operation of One Type of
Positive Displacement Meter.

Fluid flow drives the moving parts of the meter. As you can see in the various drawings, the meter cycle is designed so that discharge is continuous; while one portion of liquid is being segmented, product ahead of it is simultaneously being displaced into the discharge line.

Since the exact volume of each segment -- enclosed between the segmenting elements and the walls of the measuring chamber -- is known, and the same number of segments pass through the meter during each revolution, the exact volume of liquid that has passed through the meter can be determined from the number of revolutions of the meter. A shaft attached through the center of a rotating element of the meter and at right angles to it transfers the mechanical movement of the meter directly to the system's indicating elements.

Several different proprietary designs of positive-displacement meters are in common use for loading-rack metering systems, including the designs depicted in the preceding figures.

Because of the simple design of these devices, the number of factors that commonly cause inaccurate measurement are relatively few. One, of course, is the presence of vapor in the product flow as it passes through the meter. This will cause the meter to register more liquid product than has actually been delivered.

Meter inaccuracy can also be caused by solid contaminants that are drawn into the meter, where they can interfere with the free movement of the rotor and segmenting elements, or can score the machined and highly polished surfaces of the bores of the chamber in which the segmenting elements move. This will have the effect of widening clearances, allowing a small amount of product to slip through them. Any such slippage will tend to make the meter underregister, that is, indicate less volume of liquid product than has actually been delivered. This underscores the important function of the strainer, described in Chapter 2, and the need for its proper maintenance.

A very small amount of slippage that occurs under normal operating conditions can be effectively offset by adjustment of the registering element (see below). The rate of slippage under normal conditions depends largely upon the physical characteristics of the liquid being metered, especially its viscosity (the internal resistance of a fluid to movement). However, the rate of slippage is likely to increase at low discharge rates, or with fluctuations in product density. If the meter is relatively new, this increase in the rate of slippage will be insignificant from the point of view of measurement error.

However, as the meter wears, clearances tend to widen somewhat, and slippage is aggravated. When the resultant deterioration in accuracy indicates that a meter is badly worn (see Chapter 7 for a description of how this is determined by testing), adjustment to the registering elements will no longer be adequate, and the meter will have to be removed from the system and reconditioned.

Turbine Meters

Turbine meters, like the one depicted in Figure 3-4, have become more and more popular in recent years, since the introduction of electronic registers has made them more practical for commercial use. They have the same basic advantages of high accuracy for relatively low cost, the ability to measure accurately over a wide range of flow rates, and ease of maintenance.

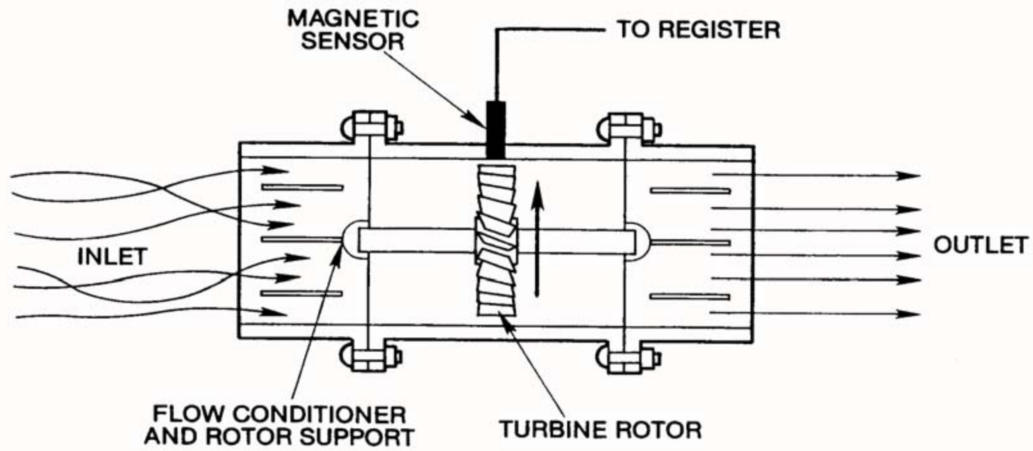


FIGURE 3-4. Turbine meter.

The principle of operation of a turbine meter is very simple. Flowing liquid is forced to pass over the blades of the turbine, causing it to spin like a windmill. The velocity of rotation is directly proportional to the rate of flow of product, so the device can be calibrated to measure flow rate. This is usually accomplished by a magnetic sensor, which detects the completion of a single rotation of the turbine and sends an electronic pulse to the registering element.

Flow straightening devices, like those shown, are often incorporated in the design of turbine meters, which have some sensitivity to turbulence: reducing turbulence is thought to enhance accuracy over a wide range of flow rates.

Unlike piston-type meters, such as those commonly used in gasoline pumps, in which the stroke of the piston can be changed by adjusting its throw, adjustments to the quantity of product passed through a rotating metering element, like those we have been looking at, in one revolution can not be made. For this reason, adjustments to bring the meter as close as possible to zero error are made through the registering element.

Mass Flow Meters

Metering systems that measure fluids (gases and liquids) in terms of mass (weight) are called mass flow meters. These systems are of two basic types. The first type, which is sometimes referred to as a "direct" mass flow meter, actually senses the mass of the product flowing through the metering system. One such device causes a loop of piping through which product is flowing to oscillate, or move continuously at a constant rate between two positions. This movement creates an acceleration in the liquid flowing through the pipe, which in turn produces a force that acts at right angles to the flow.

This force -- often referred to as Coriolis force after a nineteenth-century engineer who described the effect of the rotation of the earth on moving objects -- causes the piping to deflect slightly in the direction of the acceleration. The amount of deflection, which is measured by the device, is directly proportional to the mass of the liquid or gas in the pipe (force is equal to mass times acceleration), and can be indicated in units of mass.

In the second type, which could be considered an "indirect" or "inferred" mass flow meter, the mass measurement is derived from measurements of the properties of the product (such as volume and density or volume, temperature, and pressure) combined with an equation modeling the characteristics of the product.

Although they are a relatively new technology, mass flow meters are being used increasingly in bulk measurement applications. Consequently, a number of changes have been made recently to NIST Handbook 44 to incorporate requirements for mass flow meters. Also, there is a separate code in the Handbook to address these devices. If you encounter one of these meters in the field, you should be aware that special procedures may be required to test them. They are typically tested using gravimetric test procedures; however, you should check with your supervisor to learn what procedure is used by your jurisdiction.

INDICATING AND RECORDING ELEMENTS

The Register

The function of the registering elements is to "count" the number of revolutions made by the meter during a delivery, "compute" from this count the total volume delivered, and indicate the quantity in a manner that is clear and readable. These operations can be performed either mechanically or electronically, as we will see. In the case of positive-displacement meters, the register is linked mechanically to the revolving meter shaft. As mentioned above, turbine meters transmit electronic signals directly to the register (and are, therefore, limited to use with electronic registers).

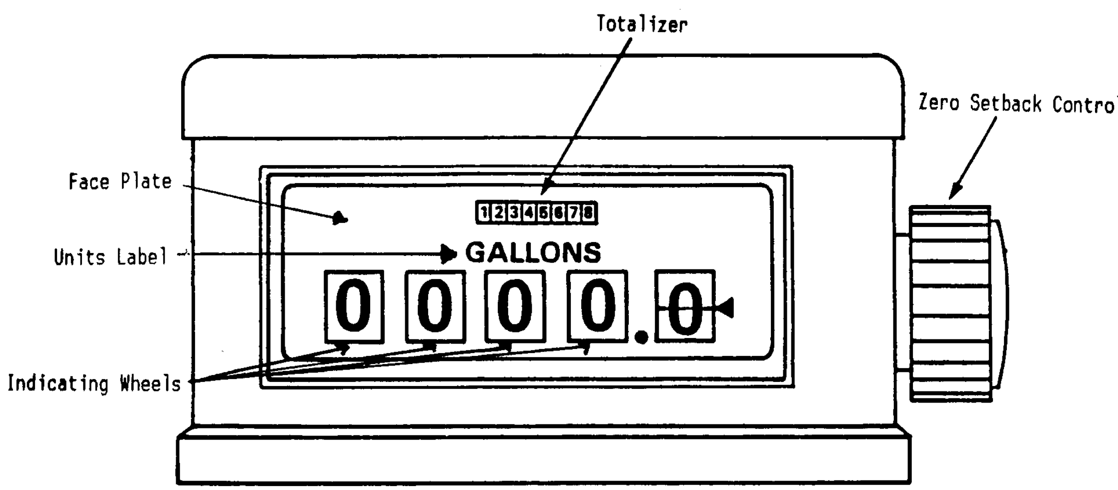


FIGURE 3-5. Mechanical register.

The mechanical register used on most loading-rack metering systems incorporates a wheel-type indicator, the type that may be familiar to you from gasoline pumps or vehicle-tank meters. (In fact, the register used may be the same as that installed on fuel oil trucks or LPG metering systems, with the only difference being in the value of the smallest unit indicated.) Figure 3-5 shows what a typical mechanical register looks like from the outside.

Inside the register, the mechanical motion of the revolving meter shaft is transferred through a gear train directly to a revolving wheel, like the one shown in Figure 3-6. This will be the right-hand indicating wheel on the register (in Figure 3-5, the wheel that indicates single gallons of product delivered). The circumference of the wheel is divided into equal segments (usually 10) and marked with graduation lines and number values.

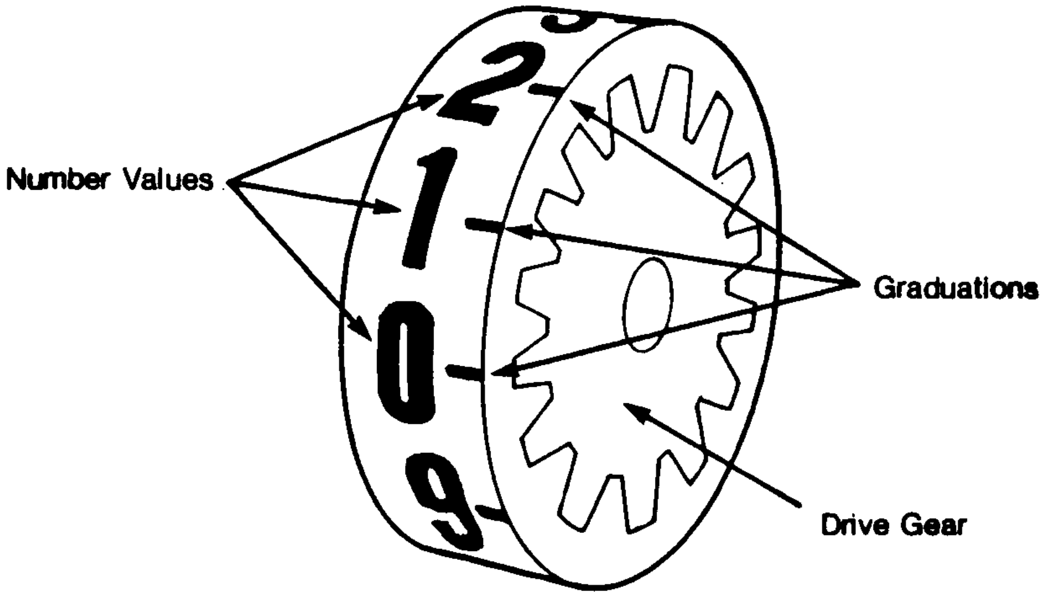


FIGURE 3-6. Right-hand indicating wheel.

The right-hand indicating wheel thus turns in correspondence with the revolution of the meter shaft. As you can see by reviewing Figure 3-5, only a portion of the wheel's circumference is visible at any time through a window in the register cover plate. A fixed indicator, usually a pointer attached to or painted on the cover plate, is used to read the quantity represented by the numbered divisions or, if the indicator stops between graduation marks, a quantity intermediate between the values associated with those graduations.

A complete revolution of this indicating wheel represents a delivery of 10 gallons. Toward the end of each revolution, the wheel turns a transfer gear that causes the wheel immediately to its left to move through one tenth of its circumference, thereby displaying its next higher number value. This process is repeated for two or more identical wheels, each turned through one tenth of its circumference by a single complete revolution of the wheel immediately to its right.

Together, the wheels represent the digits of a number; the values represented by each wheel are 10 times the values of the wheel to its right. This design permits relatively large values (the example in Figure 3-5 can register quantities of up to 99,999 gallons) to be read directly and accurately without requiring a large number of graduated scale divisions.

More and more new systems are being equipped with electronic registers, which incorporate fewer moving parts and offer additional features, such as data communication to and from remote devices, multiple-point calibration (see below), full computing capability, and many other features that make them attractive in a marketplace that is evolving rapidly with changes in technology.

Like a mechanical register, an electronic register also produces its indication from the revolution of the meter. However, in an electronic register, the mechanical motion is transformed into digital signals.

In the case of positive-displacement meters, this is accomplished by means of a device called a <u>pulser</u>. Several different designs of pulser are in use, some employing optical devices, but essentially the pulser is simply a switch that is actuated a fixed number of times by each complete revolution of the meter shaft.

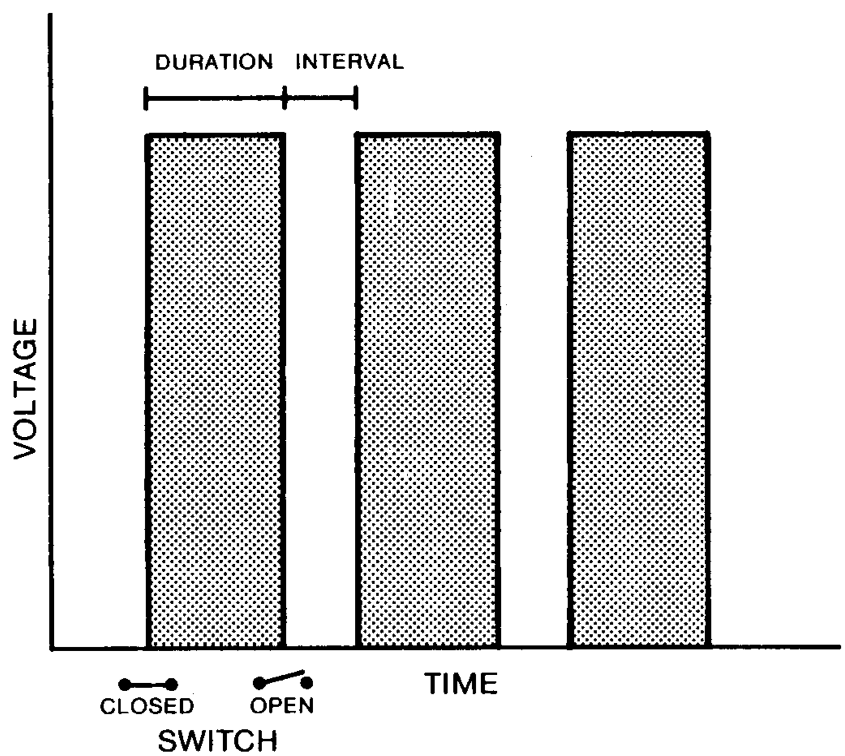
The switch is connected to a low-voltage power supply: while it is closed a current flows through the circuit; when it is opened, the current is discontinued. The result, for any full or partial revolution of the meter shaft, is a series of discrete pulses, as illustrated in Figure 3-7.

Pulsers installed in loading-rack metering systems produce from 10 to 1,000 discrete pulses per revolution of the meter shaft, depending upon the design. The pulses are transmitted to the processing circuitry of the register (which is, in fact, a small computer), which recognizes and "counts" them electronically as they are transmitted. The circuitry then produces its own signals, which drive the digital display that indicates the quantity delivered, other indicating or recording elements.

The magnetic sensing element of a turbine meter transmits the same kind of discrete pulses, the only difference being that they are generated electronically.

FIGURE 3-7. Discrete pulses.

A sophisticated electronic register, capable of many additional functions, is illustrated in Figure 3-8.



As you may be aware, the requirements established in Handbook 44 for mechanical and electronic registers differ in some respects. These differences reflect, for the most part, an important distinction between two types of indicating devices: analog and digital devices.

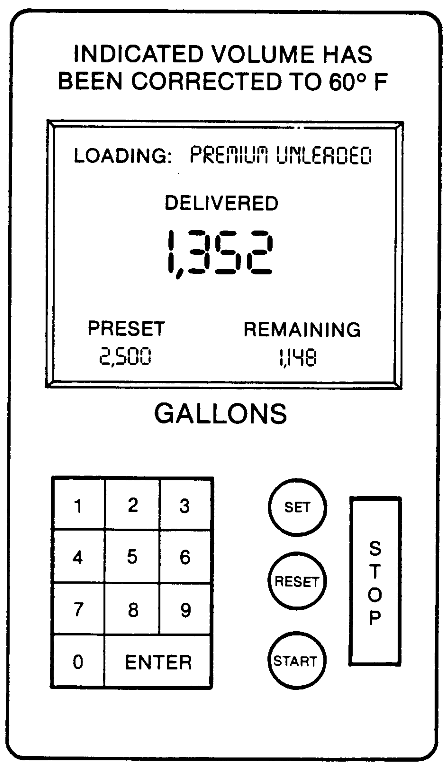
Most (although not all) mechanical registers are analog-indicating devices. A formal definition of this type is provided in the Definitions section of Handbook 44.

analog type. A system of indication or recording in which values are presented as a series of graduations in combination with an indicator, or in which the most sensitive element of an indicating system moves continuously during the operation of the device.

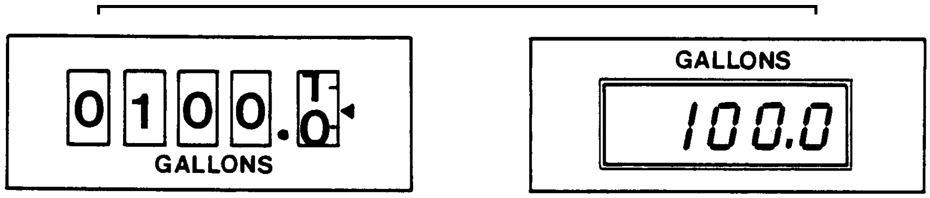
Definition of an analog-type device.

A mechanical register like the one described above meets both parts of this definition. You have seen how values are presented as a series of graduations on the right-hand indicating wheel, with a fixed indicator (the pointer) used in combination with the graduations to give a reading. In addition, the right-hand wheel is the most sensitive element of the system, since it indicates the smallest quantities, and this most sensitive element moves continuously during the operation of the device. As it moves, and one graduation after the next passes by the indicator, an infinite number of values intermediate between the graduated values are displayed (even though our ability to read these values is limited).

FIGURE 3-8. Electronic register.



Now let us look at the Handbook 44 definition of a digital-indicating device:

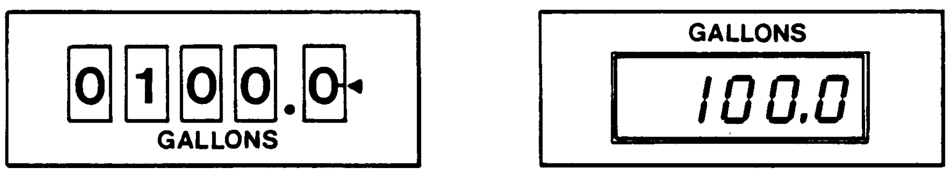


Definition of a digital-type device.

Of course, there are no graduations on a digital register display, only the numbers themselves. Furthermore, in contrast to an analog register, whose indications pass through an infinite number of intermediate values between graduations, the digital display "jumps" from one value to the next in increments.

To see how this can make a difference, first consider the indicators shown in Figure 3-9. They look quite similar, and indicate exactly the same quantity, 1,000 gallons. The indicator on the left represents an analog indicator, the one on the right a digital indicator.

FIGURE 3-9. Analog and digital indicators (I).



Now imagine that we deliver exactly the same small quantity of product from both systems. The indicators then appear as in Figure 3-10.

It is clear from the reading of the mechanical indicator on the left that some product has been delivered. We can see at a glance that slightly less than 0.5 gallon has been added to the earlier reading of 1,000 gallons, and by sub-dividing the interval on the right-hand wheel visually we can arrive at an approximate reading of 1,000.4 gal. The digital indicator on the right, however, still reads 1,000 gallons, despite the additional delivery of product, and will continue to do so until about 0.1 gal more has been delivered. The reason for this is that it is designed to "round up" to the next higher value half-way between two consecutive values.

FIGURE 3-10. Analog and digital indicators (II).

From this example, it might seem that an analog registration system is capable of providing more accurate readings than a digital system. In fact, the sensitivity of an indicating device is a function of its design: analog and digital devices are equally capable of being designed to meet the sensitivity required for their application.

The registers we have been looking at are resettable. That is, the indication may be reset to zero between successive deliveries. However, unlike systems that are used as the basis for <u>retail</u> commercial transactions, wholesale devices, like loading-rack meters, are <u>not</u> required to be equipped with resettable indications, although many are, especially those used at bulk petroleum terminals. Indicators that are not resettable are referred to as <u>totalizers</u> (see below).

On a mechanical register, the reset control is usually a lever or a knob located on the side of the register unit (as on the register shown in Figure 3-5). Operating the control all the way to its stop will turn the indicating wheels forward until all of them are in a definite zero position. The reset control on an electronic register is usually a pushbutton which, when pressed, clears the display (see Figure 3-8).

In addition, Handbook 44 requires that some effective means be provided to prevent the device from displaying <u>any</u> readable indication during the course of the resetting process (see Chapter 6 for details). Most mechanical registers are equipped with shutters that cover the indicating wheels while they are in motion during the resetting process, obscuring any possible reading until the zero indication has been reached. On electronic registers, the display is normally blanked out completely while the circuits are being cleared and reset.

Most registers are also equipped with accumulative indicators, more commonly referred to as <u>totalizers</u>. As mentioned above, totalizers may be used exclusively on wholesale metering devices, including loading-rack meters. On registers that are equipped with resettable elements, totalizers (which are visible on the register shown in Figures 3-5) are generally used by the owner or operator of the device to monitor sales and inventory, and to provide a means of detecting pilfering by employees.

As mentioned earlier, when a loading-rack metering system must be adjusted to bring its registration as close as possible to zero error, it is the register rather than the meter that is directly affected by the change. Unless it is reconditioned, the meter will continue to process the same amount of product per complete revolution at a given discharge rate; the register is instead adjusted to bring the <u>indication</u> of the delivery as close as possible to a zero-error condition.

Mechanical registers are adjusted by means of a mechanism that alters the rate of revolution of the indicating wheel relative to the revolution of the meter shaft. In some models, this is accomplished by actually changing the gears that are located between the meter and the register. Such an adjustment mechanism is called, appropriately, a "change gear" mechanism.

In this type of device, adjustments are made in increments or steps, so that a single calibrated unit of adjustment will produce a predictable change in the indication per gallon metered. For example, an adjustor might be designed to make adjustments in increments of .15 percent. That means that for each unit of adjustment made, the output shaft of the adjustor will rotate .15 percent faster or slower (depending on the direction of the adjustment) than the input shaft from the meter: the result of one unit of adjustment will therefore be a change of 1.5 gallons (346.5 cubic inches) in registration for a delivery of 1,000 gallons. If the metering system is properly designed, installed, and operated, and is not badly worn, an adjustor with this degree of sensitivity would be capable of maintaining meter accuracy within weights and measures tolerances (the most stringent of which is 2 gallons for a 1,000-gallon draft).

Another design of meter adjustor allows continuous variation of adjustment over a range of values. For example, it might be capable of infinitely variable adjustment over a range of 5 percent. The ratio of the speed of the output shaft to the speed of the register could thus be adjusted by any amount within that range. This type of adjustor is equipped with a calibrated dial or some other means to allow the operator to see how much adjustment is being made. This design is also capable of maintaining meter accuracy within weights and measures tolerance, if the meter is in good condition and the system is installed and operated correctly.

Mechanical adjustors are located between the meter and the register. In some models, access to the adjustor is gained by removing the top of the register. In others, the adjustor is located in an assembly that is accessible by removing a cover plate on the front of the meter. In any case, either the adjustor or access to it must be protected by a security seal to prevent tampering.

As you might expect, adjustment of electronic registers is performed electronically. The operator or repairperson determines a "calibration factor" based upon the errors observed during tests. This factor is keyed into the system circuitry, and subsequently corrects all registered quantities by computation. Some electronic registers can also be programmed for "multi-point" calibration. This permits different correction factors to be entered for different flow rates, and provides great precision if used correctly. The switches, dials, or other controls that are used to set the calibration factor are usually located behind a removable panel on the back or on a side of the register. This panel must also be protected by a security seal.

As said above, a meter can only be adjusted effectively when its errors are reasonably consistent for its full range of operating characteristics. A meter that is excessively worn may register erratically, and its inaccuracy will vary at different delivery rates. The adjustor can thus be considered as a fine-tuning instrument for a meter that is not badly worn or damaged. At some point, however, the adjustment mechanism will no longer be capable of correcting registration to within acceptable limits of inaccuracy. The topic of meter wear and adjustment will be discussed further in Chapter 7.

Recording Elements

Handbook 44 does not require that loading-rack metering systems be equipped to provide a permanent printed record of transactions. However, some States and a number of local jurisdictions do require a delivery ticket or invoice for wholesale transactions, whether printed or handwritten. Whether required or not, many operators make use of ticket printers because they reduce the time required to complete a transaction and eliminate errors resulting from the incorrect reading of register indications, and errors in transcription or arithmetic.

If a ticket printer is installed, it is driven directly by the register, either mechanically or electronically. Many mechanical printers are not resettable, and record only beginning and ending totalizer readings, with the total quantity computed and filled in by the operator. Electronic registers that have price computing capability may also operate with compatible printers to produce a complete invoice, recording in addition to the quantity delivered the unit price of the product, the total sale price, and other useful information, such as the date and time of the delivery.

Figure 3-11 shows examples of delivery tickets or invoices (you may also hear them referred to as bills of lading) that might be produced by a mechanical printer (on the left) and by an electronic printer (on the right). As you can see, the mechanical printer records only the beginning and ending totalizer readings; the operator must compute the actual quantity delivered and perform temperature corrections (if done) manually, and must also enter the product and meter identification and transaction information. In contrast, the electronic system provides all this information automatically; the operator need only enter the customer and operator names for verification, and performs no computations.

FIGURE 3-11. Sample printed tickets.

Handbook 44 includes a number of specific requirements relating to printed quantity representations, and other

Petro, Inc.
Terminal A
123 River Road
City, State 45678

Ticket No. 91001

DELIVERY RECEIPT

Date: 9/27/90 Time: 11:25 AM

Customer ID#: 00456

Product: DIESEL FUEL

API Gravity: 35.5 Meter No.: 26

FINISH 866927

START 864427

GROSS GALLONS DELIVERED 2,500

Product temperature: 66.5 °F

*Volume Correction Factor: .9970

*NET GALLONS DELIVERED 2,493

*Correction to Volume at 60 °F

Received by:

Petro, Inc.
Terminal B
123 River Road
City, State 45678

09-27-90
11:25 am

Transaction No.: 000091001

Driver: 000000123
Company: 000000456
Trailer: 000000789
Terminal: 000000321

Meter ID: #26

Product: DIESEL FUEL
API Gravity: 35.5

Customer:

Carrier:

Operator:

GROSS VOLUME DELIVERED: 2,500 GAL

Temperature of Load: 66.5 °F
*Volume Correction Factor: 0.9970

*NET VOLUME DELIVERED: 2,493 GAL

*Net Volume is Corrected to 60 °F

Received by:

information displayed on the invoice. You will learn about these requirements in Chapters 6 and 7.

<u>Automatic Temperature Compensating Systems (ATCSs)</u>

Many petroleum products, especially highly refined fuels like gasoline and aviation gas, are volatile (that is, they tend to evaporate readily at atmospheric pressure), and have high coefficients of thermal expansion (an average grade of gasoline expands approximately 0.07 percent in volume for every increase in temperature of 1 /F). Shrinkage of product during the winter months, especially in northern climates, can have a significant cumulative effect on inventories, since the same weight of product will be registered as a lower volume when it is cold than when it is hot. To allow for stable pricing, many suppliers customarily correct the volume of product to its volume at a reference temperature of 60 /F to compensate for product shrinkage or expansion. This practice is known as <u>temperature compensation</u>.

If a wholesale distributor buys "compensated" product, it will be very much in his or her interest to perform the same correction in order to maintain competitive seasonal prices. The practice of temperature compensation is now widespread throughout the petroleum industry.

Temperature compensation can be performed manually by the operator of a device if the temperature of the product as it passes through the meter is known, by consulting appropriate temperature correction tables. Weights and measures inspectors use this method in testing metering equipment, as you will learn in Chapter 7.

However, manual computations are time-consuming and subject to errors due to faulty thermometers, inaccurate reading by the operator, transcription errors, and arithmetic errors. As a result, most facilities now use automatic temperature compensating system (ATCSs) to perform the correction during the delivery.

A temperature probe, installed either in the meter chamber or immediately adjacent to it, senses the temperature of product during a delivery and transmits this information electronically to the ATCS. The ATCS computes an average temperature for the entire delivery, and uses temperature correction factors that are programmed into its memory to correct the indicated volume for this value. (Because it senses product temperature, the ATCS might be considered to be a measuring element; however, its output function is to derive the temperature-corrected quantity and display or record this value, so it is properly also an indicating element.)

In many models, the electronic elements of the temperature compensating system are integrated with the elements of the register, and are housed in a single chassis (as in the example in Figure 3-8). Since the system counts gross gallons and corrects the total quantity delivered, both quantities can be recorded, along with the average temperature that is used as the basis for correction.

An ATCS is usually equipped with a "lock-out" switch or some other means of deactivating it. This is necessary for testing and calibration, but should be sealed to prevent unauthorized deactivation (which is prohibited by Handbook 44 requirements and most State laws). As mentioned in Chapter 2, some means must be provided, either manual or automatic, for setting the ATCS for the density of the product. If the product density is entered manually, the adjusting element should be sealed to prevent tampering that could affect measurement accuracy.

FLOW CONTROL ELEMENTS

Air Eliminator

Although their function is not precisely to control the flow of product in the metering system, air eliminators serve an important function by conditioning the flow immediately before it passes through the meter. The purpose of an air eliminator is to remove air and/or vapor before it can enter the meter and cause overregistration. Vapor separated from the liquid flow is vented from the top of the vapor eliminator into a line which carries it to a holding container, where vapor is condensed and separated from the air, and returned in liquid form to product storage.

As described in Chapter 2, air and vapor can be introduced into the fluid flow by a variety of conditions, such as the formation of a vortex in the storage tank, a clogged strainer or any other restriction in the line before the meter, leaks on the suction side of the pump, or improper selection or installation of piping and valves.

Many of these factors can be controlled, and as explained in the last chapter, many loading-rack metering systems are well enough protected against vapor production that an air/vapor eliminator is not needed. However, some quantity of air/vapor is likely to be produced under certain conditions in any system, no matter how well designed and installed, and if it is produced in significant quantities, the air/vapor eliminator is the last line of defense against metering air/vapor along with liquid. Figure 3-13 illustrates the operation of a typical air/vapor eliminator.

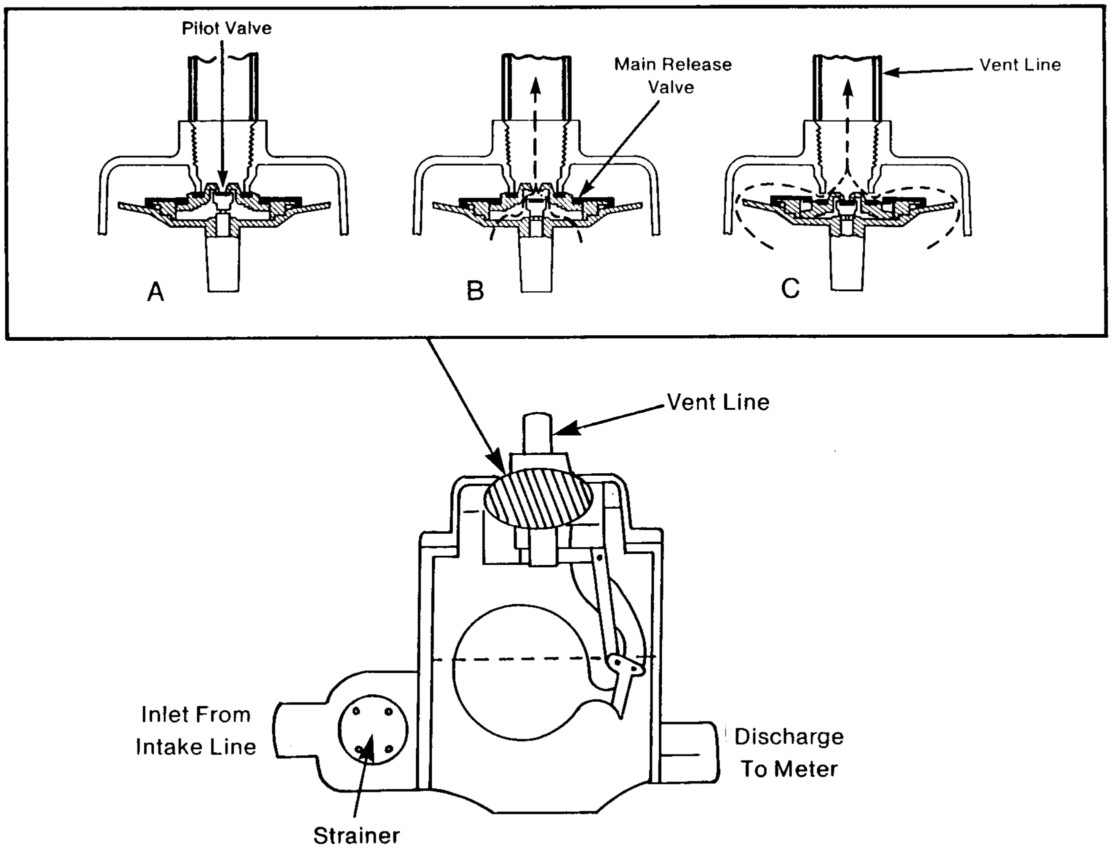


FIGURE 3-12. Typical air/vapor eliminator.

Liquid flows into the enlarged chamber, which permits separation of air and vapor from the liquid flow. Bubbles rise to the surface of the liquid, and are trapped between the liquid surface and the vent line release valve. The function of the release valve is to assure that liquid does not circulate through the vapor system when the separating chamber is full of vapor.

The device in Figure 3-12 incorporates a float and two-staged release valve. Other designs use the float with different types of release valves, and some incorporate a pressure sensor, like a diaphragm, to actuate the valve.

Air/vapor eliminators are capable of removing even relatively large quantities of unentrained gases from the product flow quite effectively. However, entrained air/vapor is very difficult to exclude, and may pass through the eliminator and into the meter.

Automatic Flow Control Valve

An automatic means of controlling discharge rate and delivery start and stop is necessitated by the high discharge rates and volume of product that are characteristic of most loading-rack metering systems. The automatic flow control valve thus takes the place of manual valves that are incorporated in smaller metering systems, such as gas pumps and vehicle-tank meters. In fact, this device fundamentally automates the entire delivery, making self-service loading-rack meters practical.

The control valve is usually, although not always, installed on the discharge side of the meter. In addition to controlling the delivery, the control valve can, in this position, also provide flow conditioning, by maintaining a constant pressure in supply line and meter. Some models are designed to detect the presence of vapor in the flow and prevent gas from being metered.

Another important feature of the flow control valve is its ability to accept input from other sensing devices, such as the overfill level sensor, quantity preset, or emergency shutoff, responding much more quickly than a human operator could. For example, by receiving input from the quantity preset, the control valve can automatically reduce the discharge rate, either at startup or in advance of shutdown. Most flow control valves are also programmable, so that they can be adapted to the operating characteristics of the system.

Quantity Preset

This component, often referred to as a quantrol (for quantity control) is also necessitated by the high flow rates generated by loading-rack systems. Along with the overfill sensor, the preset guards against overfill, by shutting off delivery precisely when the preset quantity has been delivered.

This is the only control that the operator actuates by hand in most systems. The desired total quantity of the delivery is keyed in and indicated. When the user operates a START control, the system pump is switched on and the control valve is opened automatically, in response to signals from the preset. The device also signals the control valve when to increase the discharge rate after a slow-flow startup and when to reduce it in preparation for shutdown.

Some presets are designed to "count down" the delivery, indicating continuously the quantity of product remaining to be dispensed, rather than the amount already dispensed. Presets may be either mechanical or electronic. Mechanical presets, like the one shown in Figure 3-13, are mounted on the meter stack. Electronic presets are often incorporated in the register, as in the example in Figure 3-8. Whether mechanical or electronic, the preset is ultimately driven by the meter (via the register and/or a temperature compensator), and so will reflect any inaccuracy inherent in the measurement.

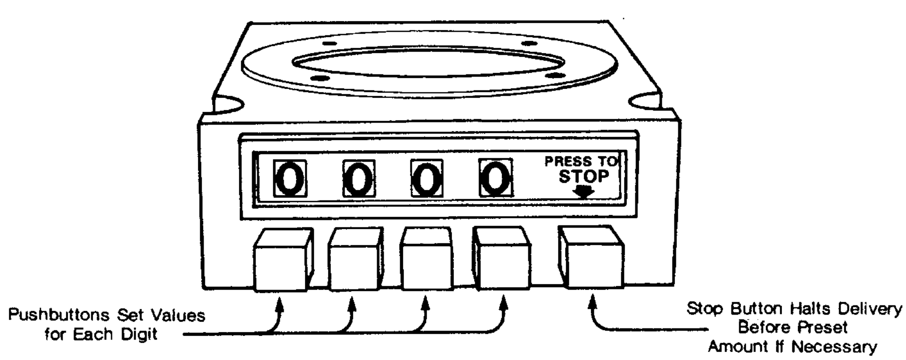


FIGURE 3-13. Mechanical Quantity Preset.

This completes our discussion of the major operating elements of a loading-rack metering system. A number of accessory components that are in common use but are optional devices not critical to the operation of most systems, and which do not affect measurement accuracy, have been omitted. You will become familiar with these accessory devices as you gain experience in the field.

SUMMARY

A number of separate operating elements work together to assure the safe, efficient, and accurate operation of a loading-rack metering system.

Most loading-rack meters are either positive-displacement or turbine meters. Indicating elements may be either mechanical or electronic, analog or digital. Meter errors are corrected by adjustments that affect the registration, not the quantity of product processed per meter cycle. Accessory devices, such as a ticket printer or automatic temperature compensator, may be incorporated in the metering unit.

Several components serve to control or condition the product flow. Some systems employ air/vapor eliminators to rid the system of gases that are produced in the supply line before the pass into the meter. The automatic flow control valve controls the flow rate precisely throughout the delivery, in response to its own programming, but also in response to input from other devices, such as the overfill sensor or quantity preset. The latter device is a necessity because of the high velocity and volume of flow. It is the primary interface between the operator and the system, and may be the only control actually operated by the user.

Specific requirements relating to the selection, design, installation, maintenance, use, and performance of these elements are described in detail in Chapters 6 and 7.